The "Neolithic Problem" Reconsidered: Human-Plant Relationships in Northern Australia and New Guinea

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INTRODUCTION

PRIOR TO ABOUT 6000–8500 B.P. Australia and New Guinea were joined as part of greater Australia (Jennings 1971). Today, those areas of both land masses that fall between about 5 and 20 degrees south latitude and whose watersheds drain into the seas adjacent to the Torres Strait appear to share a number of geographical features. These include seasonality, rainfall, temperature, and some vegetational associations (White 1971; Doutch 1972). There are also cultural affinities between the two areas, most obviously in stone tool technology. However, cultural differences also exist and these seem most apparent in subsistence strategies.

New Guinean societies are generally characterized as having been universally agricultural at the time of first European contact. Australian Aborigines have been regarded as having maintained hunting and gathering economies despite the proximity of some to New Guinea and the presence of domesticable plants and knowledge of cultivation techniques. In the Australian literature this apparent anomoly has been termed the "Neolithic Problem" (White 1971).

Using a cultural materialist approach (Harris 1968, 1979; Price 1982), this paper examines the Neolithic problem in the context of Australian and New Guinean subsistence strategies. A selective review is made of the numerous studies of particular communities to show how these particular researches have contributed to an understanding of more general aspects of human adaptation. The results demonstrate that, contrary to the findings of those who have employed more eclectic approaches which have tended to confuse the issue, the main reasons for variation in subsistence strategies across the Torres Strait were practical and mundane.

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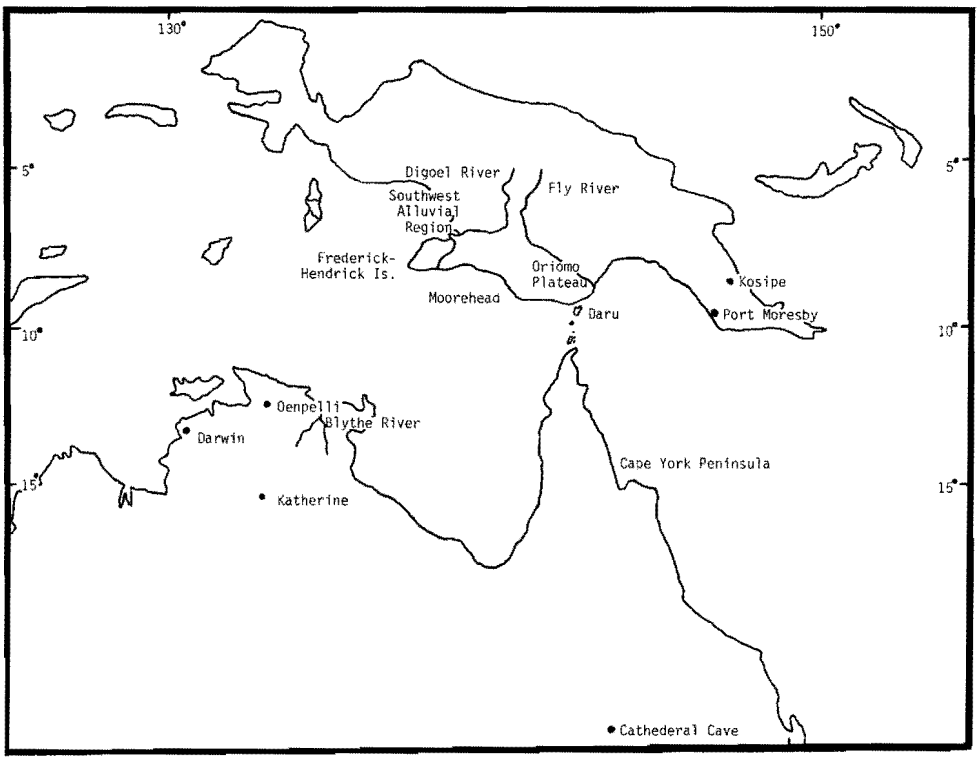

Map 1: Northern Australia and New Guinea

THE NEOLITHIC PROBLEM

Since the time of Cook, Europeans have wondered why Australian Aborigines were hunter-gatherers on one side of the Torres Strait and New Guineans were horticulturalists on the other side (Harris and Laba 1982; White and O'Connell 1982). As discussed by White, the problem is why a Neolithic revolution did not occur in Australia (1971:182). He points out that the existence of hunter-gatherers who could have, but did not, adopt cultivation techniques upset evolutionary schemes that postulated a general sequential transition from hunting to agriculture. White's article and those of others since need to be viewed in the context of change in anthropological views of hunter-gatherers that occurred in the 1960s. This change is reflected in the papers in *Man the Hunter* (Lee and DeVore 1968) and is epitomized in Sahlin's description of hunter-gatherers as the "original affluent society" (1968:85, 1972:1ff). Studies in this genre demonstrated that the subsistence activities of hunter-gatherers provided them with generally adequate nutrition for considerably less effort than agricultural activity. This directed attention to why agriculturalists opted for less leisure and often a less nutritious diet.

Prior to White's discussion of the problem in the Australian and New Guinea context, Meggitt indicated that he regarded Aboriginal religious beliefs to be the main factor that inhibited the adoption of agriculture. He added a cautionary footnote that the characteristic flora and fauna and the aridity and isolation of Australia were also variables in the issue (1964:35). Meggitt's emphasis on the cultural conservatism of Aborigines came after

ethnographers had already detailed cultural borrowings from the Macassans (Berndt and Berndt 1954) but before the extent of such external influences on material culture had received much attention (Mulvaney 1975).

Golson, taking a somewhat different apporach, also downplayed the role of ecological variables but gave emphasis to historical factors in explaining the dietary patterns of Aborigines in northern Australia. Plant species that are also found in the Malaysian region played a disproportionately large role in the diets of Aborigines in Arnhem Land and Cape York. On this basis he suggested that Aboriginal patterns of plant exploitation in these regions were probably brought from Southeast Asia before the development of horticulture (1971:207). White, using some of the same material and drawing parallels with the environment in the Trans-Fly region of New Guinea where gardening was well-established (Williams 1936), claimed that ecological factors alone could not explain the absence of agriculture in northern Australia. Instead, he accounted for its absence in terms of both religious conservatism and the affluence of coastal-zone hunter-gatherers (1971: 184–5).

A crucial element in the argument—the nature of the contrast between the societies of Australia and New Guinea—was highlighted in papers by Golson (1971) and Walker (1972). Golson reiterated his view that cultural rather than environmental or technological variables should be sought to explain the absence of agriculture in Cape York. However, he also argued that no sharp distinction existed between Australian hunter-gatherers and Papuan horticulturists, especially in light of the diversity of intensification present on islands in the Torres Strait region. Walker stated that what had been said about the absence of horticulture in Australia "sounds more like excuse than explanation" (1972:401). In contrast to Golson, he went on to say that the difference between the northern horticulturalist and the southern hunter-gatherer remains "starker and more perplexing than anywhere else in the world" (1972:405).

Golson's lead was followed by Jones (1975) in his discussion of the complexity of human-plant relationships among the Gidjingali of Arnhem Land. He indicated that plant use by Aborigines had more in common with agricultural practices than is generally assumed. Further, he suggested that only a slight degree of intensification would have resulted in the formation of economies similar to those operating north of Australia. Jones's contention that the difference in exploitation was one of degree rather than kind was important and reflected the growing trend toward closer scrutiny of the varieties of environmental exploitation among the peoples concerned.

This trend was particularly evident in the work of Harris (1977*a*) who rejected the hunter-gatherer/agriculturalist dichotomy and examined the range of subsistence strategies employed in the Torres Strait region. He highlighted population pressure as one of the incentives for resource specialization, but also emphasized that the systems observed developed as a consequence of interaction between environmental, demographic, and cultural variables.

More recently, White (1979) acknowledged that Australians managed their food production as effectively as many agriculturalists. He stated that the main difference between Australian and New Guinea societies was not gardening but the domestication of animals. He suggested that the presence of pigs in New Guinea led to the building of fences to protect plants and hence to gardens. According to White the question is no longer why Aborigines did not become agriculturalists, but why they subsisted by moving camp at less than annual intervals (1979:372). This marked an obvious shift of emphasis on the part of one of the initiators of the debate.

Much of the debate on the Neolithic problem has been similar to that between Kroeber and Sauer on the reasons for the absence of cultivation on the west coastal region of North America. This region comprised about 10 percent of the land mass but supported about 15 percent of the population, thus exceeding the population levels of the agricultural east. Kroeber postulated that although they were aware of cultivation techniques the absence of stress mitigated against the development of agriculture among the Californians. However, Sauer pointed out that the dry Californian summer prohibited the growing of maize and that adequate winter rainfall could not compensate for that dry summer. Later, Kroeber accepted this explanation for the absence of maize agriculture on the Pacific coast (1969:358). When considered in sufficient detail, environmental variables were shown to be adequate to explain the differences in Native American economies. Although the Australian and New Guinea case is not so straightforward, it is worth examining those aspects of the environment that affect plant growth in both areas.

ENVIRONMENTAL SETTING

Much of northern Australia is characterized by monsoonal wet/dry seasonality. As Gentilli (1972) indicates, the year there consists of three main and two transitional seasons. The Cool Dry Season lasts from May to mid-August. During this period humidity is low and maximum temperatures range between 26.5 and 29.5 degrees celsius. The prevailing south-east winds bring some light rain to the south-east area but little or none to the north-west. The Warm Dusty Season (mid-August to September) is characterized by gradually increasing temperatures, the subsidence of the south-east winds and little or no rainfall. During the Hot Dry-Wet Transition (October–November) temperatures continue to rise, reaching maxima in excess of 40 degrees, and the scattered showers that fall quickly evaporate. As a consequence of tropical cyclone activity the Wet Season (December–March) is characterized by an increase in humidity, cloud-cover, and rainfall. On the coastal margins this rainfall is persistent but further inland it is intermittent and lasts only a few weeks. The monsoonal effect subsides during April and in this Hot Wet-Dry Transition period there is a fall in temperature and a decrease in thunderstorm activity.

Rainfall is the critical factor in plant growth and, as Gentilli (1972:84–87) indicates, the annual total decreases from 1500 millimeters on the coast at Darwin to less than 875 millimeters some 300 kilometers inland at Katherine. This decrease in total rainfall is paralleled by a decrease in intensity and in the period of adequate rainfall. The Wet Season is characterized by short periods of rainfall in which amounts of 125–375 millimeters fall over a few days. With the cessation of rain, soils quickly dry out due to high rates of evaporation. The season of adequate rainfall (given as a minimum total of 75 millimeters within a 28-day period, measured at 14-day intervals) at Darwin is about 20 weeks long. This decreases by four weeks about every 65 kilometers to the south-southeast (Christian and Stewart 1953:27–31).

Brookfield and Hart (1971:4–21) distinguish seven rainfall regimes based on seasonality for the island of New Guinea. However, they caution that because of the effect of altitude there is great variation in temperature, rainfall, sunshine, and cloud cover over quite short distances. The area under consideration (that is, between 5 and 12 degrees south latitide) is subject to four of these regimes, running in roughly north-west to south-west bands along the southern portion of the island. The regions of high seasonality—

"large range: heavy to light, heavy dominant" and "large range: heavy to light, light dominant"—are the southern sections closest to Australia. Mean annual rainfall closely follows the pattern of seasonality and decreases towards the southern coastal areas. The regions of marked seasonality experience a mean annual rainfall of between 1500 and 3000 millimeters (with the exception of a small area on the southwest coast that receives about 1016 millimeters). Examination of mean monthly rainfall figures for these two regimes reveals that even in the driest month for the "large range: heavy to light, light dominant" area some rainfall is received (19 mm). Also, rain falls more regularly throughout the year than it does in tropical Australia. It should be noted that dry spells do occur. For example, between May and August 1957, Port Moresby experienced 100 days without rain (Brookfield and Hart 1971:14–15). Periods such as this would severely inhibit plant growth in both New Guinea and northern Australia.

Temperatures in the coastal areas of New Guinea are generally uniform, with maxima around 30 and minima around 23 degrees celsius. Humidity parallels the variation in rainfall and throughout the year there is a marked similarity of hourly changes in relative humidity, which is characteristic of lowland Melanesia (Brookfield and Hart 1971:17). High evaporation relative to rainfall occurs throughout much of the year in the "large range: heavy to light, light dominant" and "moderate range: intermediate light" rainfall regimes. This may restrict the growth of some plants for part of the year.

Important climatic differences between northern Australia and New Guinea have been indicated by Nix and Kalama (1972). First, northern Australia experiences greater variability in temperature. For part of the year mean weekly maximum temperatures in northern Australia exceed 35 degrees celsius in coastal areas (except for a narrow northeastern strip in Queensland) and 38 degrees inland; in lowland New Guinea they fall within a 32 to 35 degree range. Minimum temperatures are higher in New Guinea. There they exceed 20 degrees, compared to northern Australia which registers minima between 5 and 15 degrees celsius. In New Guinea there is less than 2.5 percent variation from mean maximum temperatures but this increases southwards and inland in northern Australia to about 12 percent at the Tropic of Capricorn. Variation in minimum temperatures follows a similar pattern. Rainfall also shows significant variation. Almost all of New Guinea receives in excess of 1500 millimeters annually, whereas this value is exceeded only in a small northeastern coastal strip of Australia. Of greater importance is the contrast in seasonality between the two areas—expressed as the distribution of the coefficient of variation in monthly rainfall. This contrast shows that, although both areas experience marked seasonality, even on adjacent coastal areas rainfall is more regular in New Guinea than in Australia (Nix and Kalama 1972:71).

Rather than drawing broad contrasts between the geomorphology of Australia and New Guinea, Mabbutt (cited in Jennings 1972) compared an area including the southern savannah of New Guinea and northern Australia with the wetter remainder of New Guinea. The critical boundary between these regions is the Fly River with well-leached lateritic soils to the south and tropical red earths to the north. Nevertheless, the more detailed analysis of Galloway and Loffler showed that in all but the modern coastal fringes, in terms of "landforms, soils and geomorphic history . . . (Australia and New Guinea) are 'different worlds'" (1972:22). Contrast in soils is particularly important. In northern Australia bedrock and unconsolidated segments have been through several sedimentary cycles and subjected to repeated erosion and deposition that has reduced their mineral composition. There are large weathered and leached areas covered by shallow soils. In contrast, in New Guinea limestone and young volcanics are common and their high rate

of erosion has caused rapid renewal of soil despite the leaching effects of the tropical climate. Consequently, in New Guinea, deeper soils are often found on considerably steeper slopes (Galloway cited in Jennings 1972:101).

At a general level, northern Australia is characterized by large areas of woodland including depauperate rain forest, grassy forest, tall and low woodland, savannah woodland, layered forest, layered woodland, and tree heath. There are also narrow strips of rainforest on the northeastern coast and a mixture of low tree savannah, tussock grassland, and shrub savannah (C.S.I.R.O. 1960). However, this broad categorization obscures a variety of microenvironmental zones (Specht 1960*a*:384–5). These include mangrove forests on the coastal fringes, large areas of tall open forest, freshwater swamps and marshes, and an admixture of forest and woodland with patches of savannah woodland in the northeast and southeast of Arnhem Land. In addition there are estuarine complexes and large areas of quartzite and sandstone hills.

In comparison, the vegetation of southern New Guinea is less complex. Most of the area under consideration is covered with floodplain forests and swamps, grasslands with a smaller area of savannah woodlands, and narrow mangrove strips on the coastal fringes. There are also some areas of rainforest on the southeastern coast and the inland portion of the southwest. Paijmans (1976:26–27) divides this into five major environmental zones. These are: (1) beach ridges and flats; (2) saline and brackish swamps with predominantly mangrove and scrub woodland vegetation; (3) lowland freshwater swamps with aquatic vegetation, swamp savannah and woodland, and forest; (4) lowland alluvial plains and fans with forest, savannah, scrubland, and grassland; and (5) hills and low mountains with mixed forest, grassland, and savannah.

Wace (1972:199–203) points out that the flora of New Guinea is of a wet tropical type related to that of Asia; that of Australia is of a dry subtropical type. Species shared by the two areas are concentrated in coastal habitats and have widespread ranges throughout the world. Some examples of vegetational discontinuity across the Torres Strait are as follows.

> Widespread in Papua, absent or poorly represented in Australia: (a) brackish swamps with *Nypa fruticans*, which is very widespread in southern Papua, but occurs only in a few small patches in north Queensland; (b) mixed mangrove swamp woodland, often with *Metroxylon* which is not present in Queensland; (c) *Octomeles*—*Artocarpus* forest of river bank and scrolls; (d) mixed *Casurina* forest; (e) semi-deciduous forest; (f) mossy and lower-montane forest.
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> Widespread and important in northern Queensland, not represented in Papua: (a) layered open forest of *Eucalyptus terradonta* and *E. polycarpa* widespread on highly leached and redeposited soils of Cape York; (b) low open forest of *Eucalyptus dichromophloia* and *E. phoenicea*, also on sands and often escarpments; (c) low layered woodlands on older quartzite rocks; (d) evergreen thickets on the Cape York sand dunes. (Wace 1972:203)

As indicated, there are important environmental differences between northern Australia and New Guinea. Before considering the effects of these on human-plant relationships it is also necessary to review the available palaeoenvironmental data (Walker 1972; Barham, in press). The Arafura Sea is shallow—40 to 80 meters deep—with gentle gradients and occasional steep, sharp breaks of slope that may be coral reef margins or laterite breakaways (Galloway and Loffler 1972). This suggests that the lack of stone resources reported for lowland areas of New Guinea, and to some extent the coastal plains of northern Australia, was likely to have occurred in the region joining the two areas at a time of lower sea level.

Webster and Streten (1972) reconstructed late Quaternary climatic conditions for the region. They concluded that it was somewhat drier than at present due to cooler sea

surface temperatures, cooler trade winds, and the effect of land areas now submerged beneath the Gulf of Carpenteria and the Timor and Arafura Seas. Rainfall on the eastern highlands of northern Queensland would have been reduced as a consequence of the drier trade winds. Areas to the west of present-day Cape York Peninsula and the Torres Strait would have been subject to fewer tropical disturbances and would have resembled the savannah of the present northern interior (1972:39). The northern part of what is now the Sahul Shelf would have received significantly more rainfall and runoff than the savannah areas to the south. This, combined with the gentle gradient of the Shelf, provided optimun conditions for the formation of freshwater swamps (Golson 1971:378). The view that there were no major drainage systems on the Sahul Shelf is supported by the results of Tyler's (1972) study of the distribution of lower vertebrate faunal remains.

A more detailed reconstruction of palaeoclimatic conditions and their effects on the vegetation of New Guinea has been provided by Powell (1976, 1977). During the period of lowest sea levels—17,000 to 14,000 B.P.—she postulated an increase in aridity and perhaps the growth of open sclerophyll forest in the Markham, Ramu, and lower Sepik valleys. Coastal and lowland vegetation types were probably similar to those of today. However, the distribution of sago—an important consideration to be discussed below—would have been restricted by the savannah areas to the south and west of the Sahul Shelf. By 8300 B.P. the climate was warmer and wetter and swampland and tropical rainforest may have occupied former open forest and savannah areas. Powell suggests that between 8000 and 5000 B.P. the warmer, wetter climate favored the expansion of tropical tuber crops, bananas, and sugarcane into highland areas (1977:18). Slight climatic deterioration since 5000 B.P. may have led to the descent of the tree line and affected forest composition. This deterioration must have also limited the differential upward expansion of the cultivation of yams, taro, and bananas.

HUMAN AND PLANT RELATIONSHIPS

A number of works (Allen 1977*a*; Beaton 1977; Bulmer 1974; Golson 1977; White and Peterson 1969; White 1971, 1979; Wright 1971) have examined various aspects of prehistoric subsistence in northern Australia and New Guinea. Despite this, our knowledge remains uneven. However, by 10,000 B.P. most major ecological zones on the Greater Australian continent were occupied. This included habitation of sites in the mountainous areas of eastern Australia and the highlands of New Guinea (Mulvaney 1975, White and O'Connell 1982:49–50).

In western Arnhem Land, White and Peterson (1969) employed both ethnographic records (Thomson 1939) and observations of contemporary hunter-gatherers to aid in their interpretation of material excavated from five rockshelters in the vicinity of Oenpelli Mission. Remains of two industrial traditions were present in the sites. The earliest of these was dated from between 20,000 and 18,000 B.P. at the plains sites of Malangangerr and Nawamoynon to about 6500 B.P. at the plateau site of Tyimede II. The shelters on the plain were occupied during the height of the last glaciation. At that time they were possibly 160 kilometers (100 miles) from the nearest coast, instead of the present-day 40 kilometers (25 miles). Some tools from the earlier tradition included thick scrapers, utilized flakes, and edge-ground axes which were possibly hafted. The latter discoveries upset previous definitions of the Neolithic as a time when ground stone tools first appeared. Other tools included stone hammers and pounders. White and Peterson (1969)

suggested that occupants of the sites exploited terrestrial marsupials and freshwater plant and animals of the inland environment.

The later industry was deposited directly above the earlier one at the same three sites. In addition it was also found at the plains site of Padypady and the plateau valley site of Tyimede I. The industry appeared about 6000 to 7000 B.P. and continued into the ethnographic present. Midden at the sites was chiefly estuarine shell suggesting that rising sea levels created estuarine conditions with a new and varied range of fauna. The continuity of estuarine shell middens up to the present led White and Peterson to conclude that there had been little environmental change in the past 7000 years. Inhabitants of the plains shelters exploited freshwater and estuarine fish and shellfish, freshwater tortoises, macropods, and other small marsupials. They also gathered a large number of plants including lotus lily rhizomes, cycad nuts, and fruits.

White and Peterson (1969) believe that the archaeological and ethnographic evidence suggests seasonal variation of residence, diet, and economy. People exploited the fish, bird, and plant resources of the estuarine plains during the dry season and retreated towards higher ground with the commencement of the wet season. There, they could hunt macropods and other animals.

Archaeological evidence from Cape York Peninsula is not as rich as the early ethnographic accounts of the region (Roth 1901; Thomson 1934). Wright's (1971) excavation at Weipa on the west coast of the Peninsula indicates a heavy reliance on shellfish. This finding is supported by the ethnographic accounts. Beaton excavated sites inland and further to the south in the Carnarvon Range. At these sites he found that the most important floral remains were seeds of the cycad, *Macrozamia moorei*, which require a complicated leaching process before they are edible (Beaton 1977, 1982). Insufficient organic material was excavated from these sites to enable an adequate reconstruction of subsistence economies. However, they are useful when judiciously coupled with ethnographic accounts. A recent and relatively detailed paper by Hynes and Chase (1982) emphasizes the microenvironmental changes that can occur over short distances and the changes in strategy needed to exploit floral and faunal resources in these environments.

To date, no lowland coastal sites in New Guinea have yielded evidence of late Pleistocene or early Holocene occupation. The earliest date for a coastal site—less than 4000 B.P. —comes from Kukuba Cave, inland from Yule Island. It has been assumed that hunting and gathering people already adapted to the exploitation of riverine and coastal environments initially settled similar environments. However, rising sea levels in the postglacial period, 14,500 to 8000 B.P. would have drowned most of the sites in those areas. The best evidence for preagricultural activity comes from montane sites. These include the sites at Kosipe, Yuku, Kafiavana, Kiowa, Batari, Aibura, Wanlek, and Manton (Mulvaney 1975).

Bulmer (1973:54–58) proposed a five stage model of increasing economic complexity for the Highlands which takes account of the considerable diversity in the proportions in which wild and cultivated plants were exploitied. In the first stage—25,000 to 11,000 B.P. —archaic hunters and collectors with "broad spectrum" economies exploited forest and grassland areas. Floral evidence from this period is limited but it is believed that pandanus species were important. In the second period—11,000 to 6000 B.P.—post-Pleistocene protoagriculturalists and hunter-gatherers were practicing generalized forest hunting, pandanus collecting, and perhaps some cultivation in forest clearings. From this period there is evidence of technological change and trade with lowland peoples. By the third stage—6000 to 3000 B.P.—there is palynological evidence of widespread forest clearance and little doubt that cultivation was widespread. There is also evidence for

the continuation of generalized hunting and pandanus collecting. In the period 3000 to 400 B.P. there was a change in settlement pattern and site use by the hunter-gatherer/agriculturalists. There was a draining of swamp areas in the upper Wahgi Valley and an increase in the number of sedentary settlements. The final period—400 B.P. to the present—is marked by the introduction and cultivation of the sweet potato.

Depending upon the results of work being undertaken in the highlands, Bulmer's scheme may have to be significantly revised. At Kuk, in the Wahgi Valley, Golson has recorded and partly excavated an extensive series of drainage ditches. The earliest of these—from what is called Phase 1—have been dated to about 9000 B.P. (1977:614). Golson has claimed that these ditches are associated with cultivation. As White and O'Connell indicate no such direct relationship has yet been established. However, archaeologically and historically documented associations between such features and agriculture from later periods "strongly reinforces the idea that all water-control systems back to 9000 B.P. were intended to assist the cultivation of plants" (1982:181). Although the data are far from complete, there is both palynological and archaeological evidence for sedentism, forest clearance, stone agricultural tools, and irrigation in the Highland valleys between 6000 and 5000 B.P. leaving little doubt of the adoption of agriculture in the Highlands by this time (Allen 1977*a*). As with northern Australia, however, evidence for plant use by the lowland and coastal dwellers has come mainly from ethnographic accounts (Eyde 1967; Harris 1977*a*, 1977*b*; Ohtsuka 1977; Rhoads 1982; Serpenti 1965; Williams 1936).

Cultivated plants introduced into New Guinea include the yams *Dioscorea alata* and *D. esculenta* which are believed to have been domesticated in Indochina (Brookfield and Hart 1971:82). Sweet potato (*Ipomoea batatas*), now a staple in many Highland populations, is of American origin and was probably introduced to New Guinea from Southeast Asia where it was taken by the Portuguese and Spanish in the fifteenth and sixteenth centuries A.D. (Yen 1971), although there is some evidence to suggest an earlier introduction (White and O'Connell 1982:183). Other introduced plants of lesser importance include some species of bananas, various beans, and the gourd (Powell 1971).

There is some uncertainty with respect to both the area of natural distribution (White and O'Connell 1982) and the area of domestication of taro, *Colocasia esculenta*. Some writers suggest that taro was initially domesticated in India (Yen and Wheeler 1968) or western Indonesia (Brookfield and Hart 1971) possibly about 4500 B.P. and that it was later introduced to New Guinea. This is Golson's view although he favors an earlier date for its introduction. On the one hand, he has suggested that growing taro may have been associated with the ditches from Phase 1 at Kuk—which have been dated to c. 9000 B.P. (1977:613). On the other hand, he believes it possible that the more developed system of ditches that appear in the second phase at Kuk c. 6000 B.P. mark such an introduction (1977:617). However, as Spriggs indicates, the possibility that taro occurred naturally in New Guinea cannot be unequivocally ruled out. That the ditches of Phase 1 at Kuk might have been associated with taro cultivation has suggested to him an independent domestication of taro in New Guinea (1982:8).

As well as introduced plants, the people of New Guinea also exploited a wide range of indigenous domesticates. These included tubers (*Cordyline terminalis* and *Peuraria lobata*), yams (*Dioscorea bulbifera, D. pentaphylla, D. hispida*), sugarcane (*Saccharum officinarum*), many green vegetables such as *Hibiscus manihot*, and the sago palm (*Metroxylon* spp.) (Allen 1977*a*). The large range of indigenous domesticates suggests that horticulture was probably established prior to the introduction of the yam and taro—if, indeed, the latter

was introduced. Horticultural activity may have initially begun as the tending of individual fruit and nut trees, thinning out plants, and perhaps the transplanting of sago palms (Powell 1976).

FOOD PLANTS

As well as those plants restricted to particular areas of northern Australia and New Guinea, Golson (1971) has indicated that both land masses share an extensive range of plant species used as food with each other and with the Malaysian region from whence the original inhabitants of Greater Australia are believed to have come. Shared Malaysian genera that are cultivated in New Guinea include *Aleurites*, *Alocasia*, *Amaranthus*, *Barringtonia*, *Colocasia*, *Dioscorea*, *Hibiscus*, *Ipomoea* (but not *I. batatas* which is of American origin), *Musa*, *Pandanus*, *Solanum* and *Terminalia*. Of these, *Dioscorea*, *Colocasia*, and *Musa* are important crops of lowland agriculturalists in southern New Guinea. According to Powell the peoples of New Guinea utilized some 1035 plant species for food, medicines, poisons, and as a source of raw materials. Of these, 251 species were food plants, of which 17 percent were always cultivated, 20 percent were cultivated and harvested from the wild, and the balance were collected exclusively from the wild (1976, 1977). However, there was considerable variability in both the availability and use of these according to environmental setting.

Various writers (Barrau 1958; Brookfield and Hart 1971; Powell 1976, 1977) have provided a generalized picture of the subsistence economies of the New Guinea lowlands and Powell (1977:14) has provided a summary. The staple for the coastal and lowland swamp dwellers was sago—both wild and cultivated. Sago was supplemented by cultivated crops such as yams, bananas, breadfruit, taro, coconut, and sugarcane and wild resources including *Bruguiera* spp., *Eugenia* sp., *Ficus* spp., *Ipomoea reptans*, ferns, seaweed, and fungi. The lowland and foothill shifting agricultural societies can be subdivided into two groups, those exploiting the grasslands and savannahs and those of the rain forest areas. The staples of the grassland and savannah groups were yams, bananas, and cassava. Supplmentary cultivated crops for these groups included taro, breadfruit, beans, *Ficus* spp., coconuts, sugarcane, and *Amaranthus* spp. Wild plants exploited included *Gnetum gnemon*, *Ficus* spp., *Peuraria* sp., and yams. The shifting agriculturalists of the lowland rain forests relied upon taro and sweet potato as staples supplemented by yams, beans, bananas, *Saccharum edule*, *Amaranthus* spp., and many other plants from their gardens. Among the wild resources they harvested *Canarium* spp., *Barringtonia* sp., *Pandanus* spp., and *Terminalia* sp.

Of particular interest with respect to the "Neolithic Problem" are those coastal dwellers whose economies were focused upon the exploitation of wild resources. Comparison of these groups with Aborigines is most likely to illuminate the collection/cultivation dichotomy. Eyde (1967) has described the importance of sago and fish in the subsistence economy of the alluvial Asmat region of southwest New Guinea. These poeple exploited five ecological zones. From the foothills they obtained mineral resources and fished small lakes; between the monsoons, they fished the coastal shelf from canoes; in the form of fish and shellfish the tidal swamps provided year-round supplies of protein; sago, the most important food, grew in freshwater swamps; and in the forest they hunted animals such as pigs, wallabies, and cassawaries and collected plants and insects. Rudimentary gardening was practiced everywhere but nowhere did it rival the importance of wild food exploitation.

Eyde's description of the daily activities of these people highlighted the crucial importance of sago—their name for sago, *amos*, was also the word for food in general. The location of sago palms upstream and fish resources downstream resulted in intensive warfare between groups that did not have access to both freshwater and tidal swamps. His linkage of the access of groups to resources, the growth of settled villages in the center of large river basins, and warfare has shown the utility of first examining infrastructural conditions when seeking to explain social organization and behavior such as incessant fighting.

Fieldwork among sago-using people was also carried out by Ohtsuka on the Oriomo Plateau (1977). This region between the Digoel and Fly Rivers is covered primarily with savannah and monsoon forest and some riverine forest and savannah woodland. The subsistence economy in the region consisted mainly of slash-and-burn horticulture, hunting, fishing, and the exploitation of both wild and cultivated sago, which was supplemented by the collection of plants and small animals and the harvesting of wild and cultivated coconuts. The most important of the plants gathered from the wild were *Canarium vitiense* and *Gnetum gnemon* collected from September to November and December respectively. The most intensive period of the annual horticultural cycle occurred early in the dry season when clearing and, occasionally, some fencing were carried out. This period was followed by planting crops such as bananas, taro, and papayas, which were harvested as required.

In his discussion, Ohtsuka notes that the people did not distinguish between planted and wild stands of sago (1977:481). Both types were owned by married men and could be inherited. In this regard, wild sago stood in contrast to all other wild plants except coconuts. Ohtsuka also indicated that there was no difference in the starch content of wild and cultivated sago and that together they accounted for about 70 percent of total caloric intake (1977:471). The advantages of sago compared with other plant foods in the region were its year-round availability, the fact that it was rarely damaged by wild animals or adverse weather, and, depending upon the method of preservation, could be stored for periods up to several months. The disadvantages of reliance upon the sago palm stem from its specific habitat of low swampy ground. This has implications for health and population density and is seen by Ohtsuka as having inhibited the elaboration of sociopolitical organization (1977:486).

The work of several investigators has clearly demonstrated that the distribution of many floral species cannot be understood independently of their exploitation by humans (Jones 1975; Hynes and Chase 1982; Rhoads 1982). Rhoads indicated how human intervention expanded the natural range of sago and drew the conclusion that the savannah environment would not have been a deterrent to further expansion of sago cultivation had the inhabitants of the lowland areas of Sahul been so inclined (1982:27). Rhoads arrived at this position despite his own description of the ecological requirements of sago. Although further work needs to be undertaken in this area, Rhoads's data, when taken in conjuction with broader environmental descriptions, suggest that there are circumscribed limits beyond which all the human intervention in the world would not have made sago cultivation a worthwhile activity.

Harris examined plant use among people occupying the littoral woodlands and swamps of the Daru coastal zone of Papua and the adjacent alluvial islands of Saibai and Boigu. Traditional subsistence was based upon limited horticulture—including tending semi-wild species—collection of plants and shellfish, fishing, and to a lesser extent on hunting turtles and dugong, as well as hunting pig, wallaby, small marsupials, and birds (1977*a*:451).

Staple crops included yams, sweet potato, taro, sugarcane, and bananas. Semidomesticated plants, besides the important sago palm, included fruit trees, species of *Eugenia* and "wild" mango, Indian almond, candlenut, *Canarium* spp., and herbs like the wild gingers of the genus *Hornstedtia*. Harris notes that most of these species were also used in the Torres Strait islands and on Cape York Peninsula but were normally gathered as wild products. Wild plants were also important, especially the cycad (*C. circinnalis*) and the edible mangrove (*Bruguiera gymnorhiza*), which were reputedly staple foods in some coastal villages. The subsistence base of this zone was characterized by Harris as a broad spectrum, mixed economy in which the limited horticulture was the only form of specialization.

In contrast to these marginally agricultural people were the inhabitants of Fredrick-Hendrick Island, situated off the southwest coast of Irian Jaya. The 7000 inhabitants of this 11,000 square kilometer island were dependent upon intensive agriculture for subsistence (Serpenti 1965). Physiographic limitations of the island include a saucer-shaped land mass with its center lower than it edges. Extensive swamping of the island occurred between January and May. As a result vegetation consisted mainly of varieties of reeds and rushes. All agricultural ground consisted of artificial islands constructed of clay, drift grass, and mud, which were raised above the marshes. Sago (which does not grow wild on the island) and taro were planted on low islands while sweet potato and yams were planted on higher islands. Despite these cultivation techniques—which Serpenti described as the most rational considering the environmental limitations of the island—subsistence was still marginal because of the annual threat of a premature onset of the wet season that threatened growth on the garden islands and *tsunami*, which ruined the harvest every five to seven years.

To compensate for these uncertainties, the diet was supplemented with many wild plants from the swamps. Chief among these was *mapie* (*Nephrolepis biserrata*), the roots of which were collected during the dry season and pounded to make flour. A nutritional analysis of the diet of these people revealed that the most important plants were cassava (a relatively recent introduction), sago, and *mapie*. This diet indicated the delicate balance between wild and cultivated plant use despite the utilization of intensive agricultural techniques. Hunting and fishing were also important subsistence activities and contributed the bulk of the limited amount of protein in the diet.

For those areas in which sago does not grow wild, such as the Moorehead district of the Trans-Fly region, gardening was the main subsistence activity. Williams (1936) listed the staple crops there as yams, followed in importance by taro, sugarcane, and bananas. These crops were grown in swidden plots tended in a yearly cycle in accordance with the marked seasonality of the climate. Although Williams described hunting and fishing activities, he made no reference to the use of wild plants. His extended observations of gardening activities suggest that wild food procurement may have been an incidental subsistence activity. It is possible that gardening has become a major activity only recently and that greater use was made of the wild food resources exploited in other coastal and lowland areas in the past (Powell 1977).

In the spectrum of New Guinean economies reviewed there are some groups, such as the people of the southwest alluvial region who exploited mainly wild resources; intensive gardeners, such as those of Fredrick-Hendrick Island, who also had to rely upon "starvation" wild plants; and groups from the Trans-Fly region for whom gardening was the major subsistence activity. None of the writers cited suggest that subsistence activity was determined by cultural or religious dictates. Eyde (1967) and Serpenti (1965), in particular, stress that the economies they studied were shrewd adaptations to very different environ-

mental conditions. This is not to imply that some foods are preferred over others. However, in terms of the bulk of the diet, material rather than nonmaterial factors were more important. Particularly apparent is the fact that, although gardens were universal, where sago is bountiful and available year-round, little emphasis was given to cultivation. This was most marked in the southwest alluvial region which had a variety of ecological zones available for exploitation.

Allen has pointed out that over most of the New Guinea landmass, gardens had long fallow periods and that half the population practiced less than intensive cultivation (1977*a*). Brookfield and Hart prepared rankings of the intensity of agricultural activity for all of New Guinea and based on these, they cautioned that there was no simple correlation between agricultural intensity and population pressure or land shortage (1971 : 94–116).

Just as research in New Guinea has provided evidence that contradicts assumptions of a uniformity of subsistence activity, studies in Australia have produced similar results. The most thorough reports of plant use in northern Australia are those which are part of the *Records of the American-Australian Scientific Expedition to Arnhem Land* (McArthur 1960; McCarthy and McArthur 1960; Specht 1960*b*).

Specht (1960*b*) recorded 105 species and varieties of plants of economic importance to the Aborigines. The majority were obtained from the monsoon forests, the savannah woodlands of the coastal dunes and sandy plains, and freshwater swamps and marshes. Most of these vegetational zones are located near the coast where marine resources were also plentiful. The monsoon forests and savannah woodlands were important throughout the year but especially so during the wet season. They supplied most of the 38 species of fruit listed as being eaten—including *Ficus* spp., *Malaisia scadens*, *Opilia amentacca*, and *Tamarindus indica*. Roots and tubers were the most important plant resource of the freshwater swamps and marshes. Of the 18 species recorded by Specht were *Dioscorea* spp. and *Ipomoea* spp. (but not *I. batatas*). The tall open forest was exploited for fruits, stems, and roots, including the nuts of the cycad palm (*Cycas media*), which were eaten from August to January.

Specht's appendix of food plant species indicates their availability on a seasonal basis. Altogether, only ten species are listed as being available throughout the year. These are: *Blechnum indicum*, a rhizome which was pounded into flour; *Livistona humilis* and *Ptychosperma elegans*, palms, the shoots of which were eaten; the tubers *Amorphallus variabilis*, *Typhonium angustilobum*, *T. brownii*, and *Ipomoea pes-caprae*; the fruit *Planchonella arnhemica*; and *Termialia* spp. including the native almond. Specht noted that the Aborigines congregated in areas where plant and animal foods were seasonally available necessitating a semi-nomadic mode of subsistence (1960*b* : 481–482).

Specht's account of the ethnobotany of Arnhem Land was complemented by McArthur's (1960) study of the total food consumption and dietary levels of Aborigines in the area. Marine resources were also an important element in the diet and included shellfish, turtle, and stingray. Hunting was not common at coastal camps but wallaby, bandicoot, lizard, and opossum were occasionally eaten. Further inland, men hunted kangaroo and smaller marsupials and both sexes netted freshwater fish.

An earlier report of subsistence activities in eastern Arnhem Land was provided by Thomson (1949). He indicated that along with various species of yam, such as *D. transversa* and *D. sativa*, the cycad formed one of the staple foods for the people of the region. Thomson also recorded the harvesting of the fruit *Buchanania muelleri* (the genus was listed by Specht) in January and February during the wet season. This fruit was sometimes dried in the sun, rubbed with red ochre, dried again, and stored for periods up to several

months. The dried fruit was pulverized and soaked in water before it was eaten. Thomson stated that this practice—and similar behavior on the part of Aborigines on western Cape York Peninsula—was an important indication of the beginnings of conservation among a nomadic hunter-gatherer group (1949:23).

More recent ethnographic research among Aborigines in Arnhem Land has shown that, although introduced foodstuffs such as rice, sugar, and flour were used as supplements, traditional procurement patterns had continued. Meehan and Jones's work among the Gidjingali of the north coast reflects increasing interest in the subsistence systems of contemporary hunter gatherers (Jones 1975; Meehan and Jones 1977; Meehan 1977, 1982; Hynes and Chase 1982). They observed the elaborate preparation of cycad nuts and their use in the provisioning of large groups of people during the *Gunabibi* ceremonies. These observations accord with those of earlier writers (Warner 1937; Berndt and Berndt 1964) and lend ethnographic support to Beaton's claim that the nuts were used as a "communion" food in prehistoric times (1977, 1982:57).

A significant point made by Specht pertained to the Aborigines' habit of leaving a fragment of a root or tuber in the ground to ensure future supplies (1960*b*). This practice was also observed by Jones (1975; see also Peterson 1976). The Gidjingali leave the top portion of tubers—especially *Dioscorea transversa* (parsnip yam)—in the ground. These recent observations have stimulated considerable interest in various aspects of Aboriginal plant management.

Jones also observed the discarding of fruit seeds at the edge of camp sites; a practice resulting in the growth of trees at such sites. Ownership of trees grown this way was acknowledged and people would only take fruit from their own sites. Jones described the relationship between people and fruit trees as a symbiotic one in which there was a selective advantage in terms of dispersal and preferred growing locations for the seeds of popular fruits.

The controlled use of fire was another aspect of plant management among the Gidjingali. Fire was used extensively in hunting activities but the people took precautions against the burning of the "jungle" (monsoon forest) where many edible plant species were to be found. Such precautions were supported by a strong ritual prohibition against interference with this zone by fire.

Meehan's (1977) study of the diet of the people living at the mouth of the Blythe River provided important information about its major caloric components. However, before reviewing her findings a note of caution is required. During the months in which food consumption was measured, purchased European foodstuffs ranged from just over 10 percent to greater than 50 percent of the total diet. These purchases consisted mainly of white flour, white sugar, and white rice. All of these foods have a high carbohydrate content and were likely to have replaced many of the vegetables exploited in the wild. Disregarding this component, in terms of calories, fish and mammals provided the greatest percentage of the diet in the month of September (Gentilli's "warm dusty season"). Fruit, nuts, and vegetables supplied less than 5 percent of the caloric intake. For the month of April (the hot wet-dry transitional period) fish were again the major component; with about 10 percent contributed by fruits and vegetables and nearly 5 percent from shellfish. The diet for the month of May (the cool-dry season) was characterized by a heavy emphasis on fish and shellfish, with plant foods contributing about 5 percent.

Meehan's study made two important points: the delineation of Aboriginal preferences for certain foods; a factor that could not be expressed in caloric counts. Prized foods included pandanus nuts, witchetty grubs, mangrove "worms" (a mollusc), and shellfish,

especially *Tapes hiantina*. The importance of coastal resources was recognized by the people who characterized themselves as "beach people" and the month of January as "shellfish time" even though shellfish in that period was not the major portion of their diet (Meehan 1977:523). More importantly, she demonstrated the wide annual variation in the availability of "staple" food resources.

In the Cape York area, recent work has been conducted by Moore (1972), Harris (1977*a*), and Hynes and Chase (1982). In particular, Harris has provided detailed information on Aboriginal plant use. On the southeastern Peninsula, the most important ecological zones were the stream channels and freshwater swamps which provided the principal starch foods—mainly palms, pandanus, sedges, and water lillies. These complemented the animal proteins obtained from terrestrial animals, fish, and birds (Harris 1977*a*:426).

Yams and other tubers, which were staple foods, grew in rocky outcrops. *Cycas media* was a major plant resource and its yield greatly exceeded quantities obtained from most other wild crops. Cycads were a managed resource. The Aborigines frequently burned stands of the plants to stimulate their asexual reproduction and yield. Harris has commented,

> Perhaps we should regard these stands as much the ecological artifacts of a particular pattern of food procurement as we do the gardens of horticulturists in the Torres Strait Islands or lowland Papua. (1977*a*:429)

On the east of Cape York peninsula, Harris was able to collect information on 86 species and varieties of food plants and to classify them in terms of the ecological zones in which they grew. Grasslands and heath were used primarily as hunting areas for wallaby, fowl, and other game. Open-canopy forests provided fruits, some starchy stems and roots, and a number of nonedible products. Rain forests were exploited for many preferred foods, particularly figs, wild bananas, and wild ginger which were available throughout the year. Coastal ecological zones—mangroves, freshwater swamps, and littoral thicket—were the main sources of staple food plants including *Bruguiera gymnorhiza*, *Eleocharis* spp., *Colocasia* spp., and *Dioscorea* spp. Significant plant protein was derived from plants such as *Tacca leontopetaloides* and *Bruguiera gymnorhiza*. However, the major portion of the diet of people in this area was derived from fish and shellfish, with extra foods being obtained through hunting.

Harris also reported the practices of leaving tuber tops in the hole from which they were dug, or breaking them off and replanting them nearby. This practice had previously been reported for the Cape York area by Lumholtz (1889) and has since been reported by Hynes and Chase (1982:40). Harris was informed that yams were never planted near houses or campgrounds as they could not grow in open areas and would be subject to disturbance by children and dogs. Traditionally, permission to dig for yams in a particular area had to be sought from the male head of the family or clan in whose territory the yams grew (1977*a*:434). Harris also reported yams planted on offshore islands to extend their distribution and to ensure a supply should mainland resources be threatened. He regards this as Aboriginal management of yams, similar to but without the labor or high yields associated with horticulture (1977*a*:437).

The subsistence activities of the people of the Torres Strait islands have been seen by some as intermediate collection/cultivation types in which both wild food procurement and horticulture were practiced with varying intensity (Beckett 1972; Harris 1977*a*; Moore 1972). For example, Moore cites historical records that described the subsistence economy on Prince of Wales (or Muralag) Island as being marine-oriented but including a

variety of wild plants such as yams and mangrove fruits (probably *Bruguiera gymnorhiza*, according to Harris 1977*a*:442). Towards the end of the dry season women would collect and store yams. Some time later, the men would replant them as a standby crop to be used only if wild yams were threatened. The only other crop planted on the island was sugarcane, although sago and tobacco were reported to have been taken to the island.

In contrast to this situation, horticulture was reasonably well established on the three northern islands of Dauan, Saibai, and Boigu where yams, then sweet potatoes, taro, bananas, and sugarcane were grown as staples in swidden plots and occassionally in house gardens (Harris 1977*a*:442–447). As part of an ongoing research effort, Harris and others are investigating the extensive prehistoric raised field systems on Saibai and adjacent mainland and lowland areas (Harris and Laba 1972). Horticulture was less important on the intermediate islands of Badu and Moa and practiced only sporadically in the Prince of Wales group.

Harris has characterized the differences in traditional subsistence systems as a gradient on which the importance of horticulture increased from south to north across the Strait and with variations in relation to size and physical resources of each island. The southern islands were larger with more diverse and abundant wild food resources. In addition the reefs around the islands provided a richer source of fish and marine animals, such as turtle and dugong. For these southern islands, subsistence focused upon the seasonal availability of yams in the dry season and mangrove fruits in the wet, with year-round exploitation of the considerable marine resources and the few terrestrial animals.

On Mabuiag and, to a lesser extent, Badu in the intermediate zone, the amount of wild food available was less than that of the larger islands and insufficient to support a permanent population (Harris 1977*a*:447). The smaller northern islands of Nagir and Dauan have few terrestrial animal resources; it has been assumed that horticulture had been practiced there for a considerable period of time. Fishing and the hunting of turtle and dugong as well as some food exchange with people from neighboring islands were also part of the traditional economy.

Harris believes that the viability of habitation on the smaller islands—especially those not in close contact with the adjacent mainland areas—depended upon population controls such as abortion, infanticide, and prolonged lactation. Less direct limits on population occurred through fighting, emigration, and deaths at sea (1977*a*:448). Haddon recognized the physical restraints imposed by these islands and remarked that "the small size of the islands and the difficulty in procuring food, especially of a vegetable character, were very strong reasons for limiting the population" (1890:359 quoted in Harris 1977*a*:448). The seasonally mobile populations of the larger islands with less intense population pressure (if only because they were not sedentary) did not need to commit themselves to full-scale horticulture.

Harris's emphasis upon a stress factor leading to intensification, has a respectable history in the literature on agricultural origins (Binford 1971; Boserup 1965; Cohen 1977; Flannery 1971; M. Harris 1979; Smith 1972). It directs attention to population densities and mechanisms of population control. Unfortunately, the demographic data for the regions under consideration are often uneven, based upon early reports of varying reliability, and subject to the effects of European contact; thus, allowing only broad and tentative comparisons.

Eyde (1967) reported that among the sago exploiters of the southwest alluvial region, both birth and death rates were high, the latter being partly due to incessant warfare over

sago and fishing resources. Higher population aggregates were found in the central areas of the region where tidal swamp and freshwater swamps intersect. Brookfield and Hart gave a generalized density estimate of between two and six persons per square kilometer for this region (1971:69). Besides the indirect limitation of overpopulation by warfare, no direct methods such as infanticide or abortion are discussed in the literature for this region. This does not necessarily mean that they did not occur but may reflect the predominance of male ethnographers who were not privy to such largely female concerns.

One of the main factors determining population density among the sago producers of the Oriomo Plateau was the number of sago palms on their land. However, even with cultivation of sago, the numbers could not be raised beyond the capacity of the swamp areas (Ohtsuka 1977). The population density for this area was less than two persons per square kilometer (Brookfield and Hart 1971:69).

Townsend's (1971) research among the Sanio-Hiowe sago gatherers of the Upper Sepik demonstrated that the availability of foods other than sago—which contributed up to 85 percent of the diet—determined population densities. As sago was not suitable for infants, the survial of newly-born children depended upon the availability of other foods such as bananas or the larvae of sago beetles for the weaning of older children. If these foods were not available and a child was born while an older sibling was still being nursed, the new infant was often killed. This practice accounted for 23 percent of infant and early childhood deaths. This case illustrates a direct density-dependent population control. As population grew to a point exerting pressure on game, fish, and vegetable resources, the people were more likely to limit their numbers by direct methods (Townsend 1971).

On Fredrick-Hendrick Island where the population density was between two and six persons per square kilometer (Brookfield and Hart 1971:69), Serpenti listed a number of practices that would have affected population numbers. While abortion seems to have been rare, he reports the infanticide of deformed children and one of a pair of twins. Serpenti mentions that postpartum taboos existed after the birth of a child but did not record how long these taboos lasted. Also of interest was the number of occasions on which sexual intercourse was prohibited. These included the planting and growing periods of certain ceremonial crops and during the time a male was making a drum. The practice of adoption among these people ensured that childless couples could relieve parents with many children of having to support them all (Serpenti 1965).

The Trans-Fly region is of particular interest because of its location immediately adjacent to the North Australian coast. Estimates of population for the Moorehead district give a density of one person per 5.2 square kilometers (Williams 1936); the Trans-Fly region as a whole had a population density of less than two persons per square kilometer (Brookfield and Hart 1971:69). These densities were lower than those of the southwest coast where the subsistence economy was based upon the exploitation of wild resources.

Little information is available on the extent of infanticide, abortion, or other methods of population control in the regions under consideration. However, while their representativeness cannot be ascertained, the sex ratios given in some of the reports are of considerable interest. One estimate for the Moorehead district gave a male to female ratio of 1.4:1; another a ratio of 1.3:1. These ratios suggest that in an area of intermittent warfare, where the adult male death rate was likely to have been higher than that of adult females, preferential female infanticide may have been practiced. Williams reported that postpartum taboos on sexual intercourse were enforced until the last child born to a woman was able to stand (1936:175). The existence of such taboos and possible infanticide suggests

that pressure on resources was being felt in the region and that gardening—although universal—was not able to give relief from periods of marginal subsistence. Such periods would have set the maximum densities of population.

Information on the demography of Australian Aborigines is far from uniform. Estimates of population density for northern Australia include Maddock's figure of between 0.5 and two persons per three square kilometers in riverine and coastal areas (1972:22–23) and Tindale's estimate of eight persons per square kilometer along the tropical north coast (1962). As Lawrence points out, the figures "hardly warrant any conclusions" (1971:259–260) as they indicate only that densities were higher on the coast and in riverine areas than in the arid center where a density of one person per 90 square kilometers (35 square miles) was reported by Meggitt (1962:32).

Analysis of the Australian demographic data is more fruitful when considered in conjunction with more general factors limiting hunter-gatherer populations. A pioneering paper in this area (subject to the above qualifications) was by Birdsell (1953) who presented evidence suggesting that, at least away from coastal and riverine environments, variations in Aboriginal population densities were a function of mean annual rainfall. This evidence led him to conclude that Aborigines had existed at the approximate carrying capacity of the environment (1953). Considering availability of food to be one of the most important determinants of local group size, Birdsell predicted that where plant and animal resources were more concentrated, as in coastal or riverine environments (or the sago swamps of New Guinea), group sizes would tend to be larger. He emphasized that, in arid areas, although groups of up to several hundred people might have temporarily congregated where food and water were available, these were not usually local groups.

Birdsell has claimed that among precontact Aborigines the male to female sex ratio was 1.5:1 (1968:236). His contention that this discrepancy—found in both arid and well-provisioned coastal zones—was indicative of female infanticide received some support in the literature (McArthur 1960; Warner 1937). (Colishaw [1978] has discussed the possible reasons for preferential female infanticide in terms of the position of women in Aboriginal society and the attitudes and motivations that generated.) Birdsell related this practice to the difficulties of nursing in a mobile population and the fact that the effects of lactation alone would not have been sufficient to maintain density equilibria (1968:243).

The indications are that in precontact times, Aborigines throughout the continent lived in small groups that rarely exceeded 25 people. Such groups aggregated to form larger populations whenever food and water supplies permitted. Ethnographic accounts of this pattern are also supported by archaeological evidence. Beaton (1977) reports that, at Cathederal Cave, midden deposits containing *Macrozamia* suggest an occupation by a large group (50–100 people) for one to two weeks.

In terms of population density, it appears that the gardening economies of the Trans-Fly region could support no more people than the semi-nomadic hunting and gathering economies of northern Australia (or, for that matter, those of more temperate regions [Lourandos 1977]). The highest lowland densities and large settled communities were found among the predominantly hunter-gatherer groups subsisting on sago and marine resources. Isolated, relatively high population densities were also apparent on Fredrick-Hendrick Island where intensive gardening was necessary for survival.

The subsistence tools employed by New Guineans and Australians were quite similar. Digging sticks, spades (largely confined to New Guinea), and ground stone-cutting tools were the basic implements and these were complemented by carrying bags made from fiber (White 1979). Contrary to those evolutionary schemes based upon increasing tech-

nological complexity, stone tools in these regions did not indicate the level of exploitative capacity. New Guinea did not share the technological innovations known collectively as the "Australian Small Tool Tradition" (Gould 1969). Instead, the stone tool technology of New Guinea became less complex in the period 10,000 to 1000 B.P. However, in the same period there was a shift from hunting and gathering to increasingly intensive cultivation, which supported large populations in the Highland areas (White 1977).

Groups in Australia and New Guinea exploited wild foods that required complex processing. In New Guinea, sago production involved the felling of palms, pounding of the pith, and the extraction of the starch. While the only tools required were a stone axe and a wooden pounder, the extraction of the starch was difficult. Similarly, in Australia, the leaching process required to detoxify cycad nuts was a complex procedure. The nuts were gathered, dehusked, crushed, and secured in a string bag before being placed into a prepared waterhole. There they were left for approximately seven days, after which time they were removed and ground into a flour-like mixture, shaped into loaves, and baked in an earthen oven. The dough provided sustenance for up to six weeks during large ceremonial gatherings (Meehan and Jones 1977; Beaton 1982).

Items of material culture and foodstuffs were included in large-scale trade networks located within Melanesia and across the Torres Strait. Archaeological evidence from the south coast of Papua demonstrated the presence of ceramic-using peoples there between 3000 and 2500 B.P. The economies of these peoples were based upon undifferentiated mixed gardening, hunting, and fishing with marine exploitation predominating. They traded pottery, obsidian, axe/adzes, and shell ornaments (Allen 1977*c*; Bulmer 1974). From about 1000 B.P. there is evidence of large-scale movement of people to the coastal area. This movement is assumed to have caused considerable population pressure and a trend towards specialized production in some areas (Allen 1977*b*, 1977*c*). Such specialization is exemplified by the Motu from the vicinity of Port Moresby. They were marine exploiters par excellence with a complex fishing technology. However, as the aridity of the area prohibited more than isolated gardening, the Motu were dependent upon trade with inland groups for vegetables, terrestrial animals, fibers, and stone axes. In addition, they obtained canoe hulls and sago from peoples of the Papuan Gulf (Allen 1977*b*).

Trade also flourished among the inhabitants of Arnhem Land where extensive ceremonial networks were in evidence. These networks became highly elaborated after the introduction of Indonesian items such as iron and dugout canoes (Thomson 1949). Food was rarely exchanged but each large gathering was dependent upon seasonally abundant items such as the cycad nut. Beaton has suggested that large ceremonial gatherings during which goods were exchanged may have been the means by which technological advances—such as those of the Small Tool Tradition—spread rapidly throughout the continent (1977, 1982:57).

The northern Australians had no inland gardeners with whom they could trade for food. The increase in aridity with distance from the coast precluded such resource specialization. However, trade and ceremonial exchanges within Australia played an important role in Aboriginal subsistence patterns. They ensured that irregularities in the supply of food resources could be overcome by the extension of foraging activities into the territories of distant trading partners with whom bonds had been formed.

Trade was also important for the Torres Strait Islanders whose networks bridged the main land masses. From Papua they obtained canoe hulls and other items of material culture and from Australia wood and red ochre. In addition vegetable and marine products were circulated between the island communities themselves (Beckett 1972).

CONCLUSION

The earliest formulations of what became known as the "Neolithic Problem" were based upon false assumptions and a misleading dichotomy. Since Cook's time European observers have asked why, given a basically similar set of environmental conditions, New Guineans, on one side of the Torres Strait, were agriculturalists while Australian Aborigines, on the other side, were hunter-gatherers. Among anthropologists, the assumption of environmental homogeneity led them to seek an answer to the question in other than infrastuctural terms. Meggitt (1964), for example, emphasized the religious conservatism of Aborigines as an important factor in their nonadoption of horticulture. However, this formulation ignored the fact that such conservatism did not prevent the Aborigines from adopting many technological items from the Macassans or from modifying their religious beliefs as a result of those contacts. These changes suggest that religious belief was unlikely to have inhibited the spread of horticulture. In general terms, anthropological findings suggest that religious philosophy may affect differential access to and/or distribution of food resources, but there is little convincing evidence to suggest that it prevents the adoption of technology that results in demonstrable improvements in the subsistence base.

Golson's (1971) explanation of the problem was also based on the assumption of environmental similarity. He cataloged the floral similarities between Australia, New Guinea, and the Southeast Asia region and noted the number of these which people from the three regions shared as food plants. His essentially historical solution postulated that Aboriginal subsistence patterns were taken to Australia by its earliest inhabitants before the development of horticulture in New Guinea. Even White's earliest attempt to deal with the problem assumed environmental homogeneity (1971:185). This led him to propose a solution to the problem that emphasized both the affluence of northern Australian societies and their religious conservatism. Earlier attempts to deal with the "Neolithic Problem" often ignored evidence of environmental differences between southern New Guinea and northern Australia. However, an increasing amount of research has rendered untenable assumptions of homogeneity. In the first place, there are important climatic differences between the adjacent land masses. South of the highlands, New Guinea experiences a greater number of rainfall regimes than does northern Australia. Although, in broad terms, the area south of the Fly River and northern Australia share a "large range: heavy to light, light dominant" rainfall regime, the classification subsumes some important differences. The area north of the Torres Strait receives more annual rainfall, it falls with less variation, and at least some falls in each month of the year. In addition to climatic differences there are also important geomorphological differences. North of the Fly River the older alluvial plains consist of weathered red clays; to the south and west of the Fly the soils have been more recently deposited and are less weathered. In contrast, the predominant geomorphological feature of northern Australia consists of plains covered by older, shallow, and weathered soils.

The climatic and geomorphic differences are reflected in vegetation patterns. North of the Fly and along the Digoel River are extensive areas of lowland rain forest. To the south, this gives way to a belt of flood-plain forests and swamps, a belt of grasslands and savannah woodlands, and a narrow coastal strip of mangroves. In contrast—although there is much local variation—the vegetation of northern Australia consists predominantly of low layered woodland and tree savannah with some strips of rain forest along the east coast of Cape York Peninsula. Although Australia and New Guinea share a number of

plant genera, in general the flora of New Guinea has greater affinity with that of Southeast Asia than with Australia.

Just as the assumption of environmental homogeneity has proved untenable, so has the dichotomy between New Guinean horticulturalists and Australian hunter-gatherers. On the New Guinea side of the Strait there was a range of societies from those who were primarily hunter-gatherers to those whose main subsistence activity was gardening. Between these extremes were other societies whose members practiced various combinations of these activities. However, the difference between the societies practicing these modes of subsistence was not in the contrast between basic activities, but resided in the degree of intensity with which they practiced certain shared plant management techniques. Australian Aborigines also shared those techniques with some of the New Guinean societies and could be classed as employing less intensive forms of plant management. Aborigines also shared a similar extractive tool kit with their northern neighbors, and they practiced similarly complex methods of processing plant products, which would otherwise have been inedible. Plant use by Aborigines represented at least incipient horticulture, indicating that neither ignorance nor ideational factors prevented them from entering the Neolithic revolution.

Increasing recognition that the differences to be explained were between hunter-gatherers and horticulturalists—not between Australians and New Guineans—and that these differences lay primarily in the intensity of exploitation led to a fundamental change in the formulation of the "Neolithic Problem." This led White (1979) to ask why Aboriginal societies did not intensify production in the manner of some New Guinean societies.

David Harris has suggested that there are three necessary conditions to be met for the transition from food gathering to food production. These are:

> (i) the operation of one or more stress factors of sufficient magnitude and duration to disturb the equilibrium of a hunter-gatherer subsistence system to such an extent that new techniques are developed; (ii) a physical environment or ecological setting which is suited to cultivation and affords the possibility of a plant and/or animal domestication; and (iii) techniques of exploitation appropriate to the new subsistence strategy. (1977*b*:181)

Of these, only the third condition was unambiguously met in northern Australia. The existence of the second condition remains a moot question. Certainly, in northern Australia there was no single staple that could provide a year-round supply of carbohydrates. Thus, although both the Aborigines and the Asmat were "affluent" hunter-gatherer societies—as attested by time budgets, nutritional analyses, and population densities—there was an important difference between them. That difference was the sedentism the availability of sago permitted the Asmat. Aborigines had to relocate their camps on at least some occasions each year to follow the availability of food supplies.

The greater aridity of northern Australia may have had important consequences for the growth of plants that were shared by both regions and that had been domesticated in New Guinea. Whether or not such plants could have been easily domesticated in Australia requires further investigation. However, it is worth noting that after 150 years of European settlement in tropical Australia the search for a successful staple crop still continues (Mulvaney 1975:239).

Harris's (1977*b*) third condition—the operation of one or more stress factors—appears to have been absent from northern Australia. At the present time it is not possible to unambiguously identify possible stress factors that led to intensification among some New

Guinean societies. According to Harris, the stressors leading to intensification are, primarily, intermediate scale changes in the environment leading to reduction in the availability of staple resources and the interaction of these with demographic variables (including both direct and indirect population controls). Although direct archaeological evidence for the relationship is lacking, in New Guinea—as elsewhere in the world—the prime factor leading to the emergence of horticulture is often assumed to be post-Pleistocene environmental change. It has been postulated that climatic change, reduction in the availability of resources, and an increase in population density due to reduced land mass led to intensification. The particular form that such intensification took would have been dependent upon the characteristics of particular environments, their ability to support populations of a certain density, and the population controls that a society instituted.

Research over the past 20 years has led to the realization that the question first put by Cook as to the nature of the contrast between Australian and New Guinean societies was the *wrong* question. This research has led to the clarification of the issues and to the posing of new questions. Although no one studying these societies has employed an explicitly cultural materialist research strategy, many of the studies complement or are compatible with such an approach. Most of the advances in this area have come about as a result of paying specific attention to environmental and infrastructural variables. It is believed that by continuing to focus on such factors we will obtain the most satisfactory answers to the outstanding questions.

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REFERENCES

ALLEN, J.
1977*a* The hunting neolithic: adaptations to the food quest in prehistoric Papua New Guinea. In *Hunters, Gatherers and First Farmers Beyond Europe*, edited by J. V. S. Megaw. Leicester: Leicester University Press.
1977*b* Management of resources in prehistoric coastal Papua. In *The Melanesian Environment: Change and Development*, edited by J. H. Winslow. Canberra: Australian University Press.
1977*c* Sea traffic, trade, and expanding horizons. In *Sunda and Sahul*, edited by J. Allen, J. Golson and R. Jones. London: Academic Press.

BARHAM, A. J.
in press The prehistory and paleoecology of Torres Strait. In *Quaternary Land Bridges: Human Migration Across Straits and Channels*, edited by N. C. Flemming and P. Maskos. New York: Academic Press.

BARRAU, J.
1958 *Subsistence Agriculture in Melanesia*. Honolulu: Bernice P. Bishop Museum, Bulletin 219.

BEATON, J. M.
1977 Dangerous harvest: investigations in the Late Prehistoric occupation of Upland South-East Central Queensland. Ph.D. dissertation, Australian National University.
1982 Fire and water: aspects of Australian Aboriginal management of cycads. *Archaeology in Oceania* 17:59–67.

BECKETT, J. R.
1972 The Torres Strait Islanders. In *Bridge and Barrier: The Natural and Cultural History of Torres Strait*, edited by D. Walker. Department of Biogeography and Geomorphology, Australian National University, Publication BG/3.

BERNDT, R. M., AND C. H. BERNDT
1954 *Arnhem Land: Its History and Its People*. Melbourne: Cheshire.
1964 *The World of the First Australians*. Sydney: Ure Smith.

BINFORD, L. R.
1971 Post-pleistocene adaptations. In *Prehistoric Agriculture*, edited by S. Struever. New York: Natural History Press.

BIRDSELL, J.
1953 Some environmental and cultural factors influencing the structure of Australian Aboriginal populations. *American Naturalist* 87:171–207.
1968 Some predictions for the Pleistocene based on equilibrium systems among recent hunter-gatherers. In *Man the Hunter*, edited by R. B. Lee and I. DeVore. Chicago: Aldine.
1971 Ecology, spacing mechanisms and adaptive behavior in Aboriginal land tenure. In *Land Tenure in the Pacific*, edited by R. Crombie. Melbourne: Oxford University Press.

BOSERUP, E.
1965 *The Conditions of Agricultural Growth*. Chicago: Aldine.

BROOKFIELD, H. C., AND D. HART
1971 *Melanesia: A Geographical Interpretation of an Island World*. London: Methuen.

BULMER, S.
1974 *Settlement and economy in prehistoric Papua New Guinea*. Working Paper in Archaeology, No. 30. Department of Anthropology, University of Auckland.

CHRISTIAN, C. S., AND G. A. STEWART
1953 General report on a survey of the Katherine-Darwin Region, 1946. CSIRO Land Res. Ser., No. 1.

COHEN, M. N.
1977 *The Food Crisis in Prehistory*. New Haven: Yale University Press.

COLISHAW, G.
1978 Infanticide in Aboriginal Australia. *Oceania* 48:262–283.

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION (C.S.I.R.O.)
1960 *The Australian Environment*. Melbourne: C.S.I.R.O.

DOUTCH, H. F.
1972 The paleogeography of northern Australia and New Guinea and its relevance to the Torres Strait area. In *Bridge and Barrier: The Natural and Cultural History of Torres Strait*, edited by D. Walker. Department of Biogeography and Geomorphology, Australian National University, Publication BG/3.

EYDE, D.
1967 Cultural correlates of warfare among the Asmat of South-West New Guinea. Ph.D. dissertation, Yale University.

FLANNERY, K. V.
1971 Origins and ecological effects of early domestication in Iran and the Near East. In *Prehistoric Agriculture*, edited by S. Struever. New York: Natural History Press.

GALLOWAY, R. W., AND E. LOFFLER
1972 Aspects of geomorphology and soils in the Torres Strait Region. In *Bridge and Barrier: The Natural and Cultural History of Torres Strait*, edited by D. Walker. Department of Biogeography and Geomorphology, Australian National University, Publication BG/3.

GENTILLI, J.
1972 *Australian Climate Patterns*. Melbourne: Thomas Nelson.

GOLSON, J.
1971 Australian Aboriginal food plants: some ecological and culture-historical implications. In *Aboriginal Man and Environment in Australia*, edited by D. J. Mulvaney and J. Golson. Canberra: Australian National University Press.
1977 No room at the top: Agricultural intensification in the New Guinea highlands. In *Sunda and Sahul*, edited by J. Allen, J. Golson, and R. Jones. London: Academic Press.

GOULD, R. A.
1969 Puntutjarpa rockshelter: a reply to Messrs. Glover and Lampert. *APAO* 4:229–237.

HADDON, A. C.
1890 The ethnography of the western tribe of Torres Straits. *JRAI* 19:297–400.

HARRIS, D. R.
1977*a* Subsistence strategies across the Torres Strait. In *Sunda and Sahul*, edited by J. Allen, J. Golson, and R. Jones. London: Academic Press.
1977*b* Alternative pathways to agriculture. In *Origins of Agriculture*, edited by C. A. Reed. The Hague: Mouton.
1979 Foragers and farmers in the western Torres Strait Islands: an historical analysis of economic demographic and spatial differentiation. In *Social and Ecological Systems*, edited by P. C. Burnham and R. F. Ellen. London: Academic Press.

HARRIS, D. R., AND B. LABA
1982 The mystery of the Papuan mound builders. *The Geographical Magazine* 54:386–391.

HARRIS, M.
1968 *The Rise of Anthropological Theory*. New York: Crowell.
1979 *Cultural Materialism: The Struggle for a Science of Culture*. New York: Random House.

HOPE, G. S.
1973 The vegetation history of Mt. Wilhelm. Ph.D. dissertation, Australian National University.

HYNES, R. A., AND A. K. CHASE
1982 Plants and domiculture: Aboriginal influence upon plant communities in Cape York Peninsula. *Archaeology in Oceania* 17:38–50.

JENNINGS, J. N.
1971 Sea level changes and land links. In *Aboriginal Man and Environment in Australia*, edited by D. J. Mulvaney and J. Golson. Canberra: Australian National University Press.
1972 Discussion of the physical environment around Torres Strait and its history. In *Bridge and Barrier: The Natural and Cultural History of Torres Strait*, edited by D. Walker. Department of Biogeography and Geomorphology, Australian National University, Publication BG/3.

JONES, R.
1975 The neolithic, the palaeolithic and the hunting gardeners: man and land in the Antipodes. In *Quaternary Studies: Selected Papers from IXth INQUA Congress, Christchurch, New Zealand, 2–10 December 1973*. Bulletin 13. Wellington: Royal Society of New Zealand.

KROEBER, A. L.
1969 Relations of environmental and cultural factors. In *Environment and Cultural Behavior*, edited by A. P. Vayda. New York: Natural History Press.

LAWRENCE, R.
1971 Habitat and economy: a historical perspective. In *Aboriginal Man and Environment in Australia*, edited by D. J. Mulvaney and J. Golson. Canberra: Australian National University Press.

LEE, R. B., AND I. DEVORE, EDS.
1968 *Man the Hunter*. Chicago: Aldine.

LOURANDOS, H.
1977 Aboriginal spatial organization and population: South-western Victoria reconsidered. *APAO* 12: 202–225.

LUMHOLTZ, C.
1889 *Among Cannibals*. London: Murray.

MCARTHUR, M.
1960 Food consumption and dietary levels of groups of Aborigines living on naturally occurring foods. In *Records of the American-Australian Expedition to Arnhem Land*, Vol. 2, edited by C. P. Mountford. Melbourne: Melbourne University Press.

MCCARTHY, F. D., AND M. MCARTHUR
1960 The food quest and the time factor in Aboriginal life. In *Records of the American-Australian Expedition to Arnhem Land*, Vol. 2, edited by C. B. Mountford. Melbourne: Melbourne University Press.

MADDOCK, K.
1972 *The Australian Aborigines: A Portrait of their Society*. London: Allen Lane/Penguin.

MEEHAN, B.
1977 Man does not live by calories along: The role of shellfish in coastal cuisine. In *Sunda and Sahul*, edited by J. Allen, J. Golson, and R. Jones. London: Academic Press.
1982 *Shell Bed to Shell Midden*. Canberra: Australian Institute of Aboriginal Studies.

MEEHAN, B., AND R. JONES
1977 Preliminary comments on the preparation of *Cycas Media* by the Gidjingali of coastal Arnhem Land. Appendix to J. M. Beaton, Dangerous harvest: Investigations in the Late Prehistoric occupation of upland South-East Central Queensland [1977]. Ph.D. dissertation, Australian National University.

MEGGITT, M. J.
1962 *Desert People*. Sydney: Angus and Robertson.
1964 Aboriginal food-gatherers of tropical Australia. In *The Ecology of Man in the Tropical Environment*. International Union for the Conservation of Nature and Natural Resources, IXth Technical Meeting, Proceedings and Papers (pub. Ser 4). Morges: IUCN.

MOORE, D. R.
1972 Cape York Aborigines and Islanders of Western Torres Strait. In *Bridge and Barrier: The Natural and Cultural History of Torres Strait*, edited by D. Walker. Department of Biogeography and Geomorphology, Australian National University, Publication BG/3.

MULVANEY, D. J.
1975 *The Prehistory of Australia*. Ringwood: Pelican Books.

MULVANEY, D. J., AND J. GOLSON, EDS.
1971 *Aboriginal Man and Environment in Australia*. Canberra: Australian National University Press.

NIX, H. A., AND J. D. KALAMA
1972 Climate as a dominant control in the biogeography of northern Australia and New Guinea. In *Bridge and Barrier: The Natural and Cultural History of Torres Strait*, edited by D. Walker. Department of Biogeography and Geomorphology, Australian National University, Publication BG/3.

OHTSUKA, R.
1977 The sago eaters: an ecological discussion with special reference to the Oriomo Papuans. In *Sunda and Sahul*, edited by J. Allen, J. Golson, and R. Jones. London: Academic Press.

PAIJMANS, K.
1976 Vegetation. In *New Guinea Vegetation*, edited by K. Paijmans. New York: Elsevier.

PETERSON, N.
1976 Ethnoarchaeology in the Australian iron age. In *Problems in Economic and Social Archaeology*, edited by I. M. Longworth and K. E. Wilson. London: Duckworth.

POWELL, J. M.
1976 Ethnobotany. In *New Guinea Vegetation*, edited by K. Paijmans. New York: Elsevier.
1977 Plants and environment in the island of New Guinea. In *The Melanesian Environment: Change and Development*, edited by J. H. Winslow. Canberra: Australian National University Press.
1982 Plant resources and palaeobotanical evidence for plant use in the Papua New Guinea Highlands. *Archaeology in Oceania* 17:28–37.

PRICE, B. J.
1982 Cultural materialism: a theoretical review. *American Antiquity* 47:709–741.

RHOADS, J. W.
1982 Sago management in Melanesia: an alternative perspective. *Archaeology in Oceania* 17:20–27.

ROTH, W. E.
1901 Food, its search, capture and preparation. *North Queensland Ethnography Bulletin* No. 3.

SAHLINS, M.
1968 Notes on the original affluent society. In *Man the Hunter*, edited by R. B. Lee and I. DeVore. Chicago: Aldine.
1972 *Stone Age Economics*. Chicago: Aldine-Atherton.

SERPENTI, L. M.
1965 *Cultivators of the Swamps: Social Structure and Horticulture in a New Guinea Society*. Assen: Van Goraim.

SMITH, P. E. L.
1972 Changes in population pressure in archaeological explanation. *WA* 4:5–18.

SPECHT, R. L.
1960*a* The climate, geology, soils and plant ecology of the northern portion of Arnhem Land. In *Records of the American-Australian Scientific Expedition to Arnhem Land*, vol. 3, edited by R. L. Specht and C. P. Mountford. Melbourne: Melbourne University Press.
1960*b* An introduction to the ethnobotany of Arnhem Land. In *Records of the American-Australian Scientific Expedition to Arnhem Land*, Vol. 3, edited by R. L. Specht and C. P. Mountford. Melbourne: Melbourne University Press.

SPRIGGS, M.
1982 Taro cropping systems in the Southeast Asian-Pacific Region: archaeological evidence. *Archaeology in Oceania* 17:7–15.

THOMSON, D. F.
1934 The dugong hunters of Cape York. *JRAI* 64:237–264.
1939 The seasonal factor in human culture. *Proceedings of the Prehistoric Society* 5:209–221.
1949 *Economic Structure and the Exchange Cycle in Arnhem Land*. Melbourne: Melbourne University Press.

TINDALE, N. B.
1962 Some population changes among the Kaiadilt people of Bentinck Island, Queensland. *Records of the South Australian Museum* 14:297–336.

TOWNSEND, P. K.
1971 New Guinea sago gatherers: a study of demography in relation to subsistence. *Ecology, Food and Nutrition* 1:19–24.

TYLER, M. J.
1972 An analysis of the lower vertebrate faunal relationships of Australia and New Guinea. In *Bridge and Barrier: The Natural and Cultural History of Torres Strait*, edited by D. Walker. Department of Biogeography and Geomorphology, Australian National University, Publication BG/3.

VAN ARSDALE, P. W.
1978 Activity patterns of Asmat hunter-gatherers: a time budget analysis. *Mankind* 11:453–460.

WACE, N. M.
1972 Discussion on the plant geography around Torres Strait. In *Bridge and Barrier: The Natural and Cultural History of Torres Strait*, edited by D. Walker. Department of Biogeography and Geomorphology, Australian National University, Publication BG/3.

WALKER, D.
1972 Bridge and barrier. In *Bridge and Barrier: The Natural and Cultural History of Torres Strait*, edited by D. Walker. Department of Biogeography and Geomorphology, Australian National University, Publication BG/3.

WARNER, W. L.
1937 *A Black Civilization*. New York: Harper.

WEBSTER, P. J., AND N. A. STRETEN
1972 Aspects of late quaternary climate in tropical Australia. In *Bridge and Barrier: The Natural and Cultural History of Torres Strait*, edited by D. Walker. Department of Biogeography and Geomorphology, Australian National University, Publication BG/3.

WHITE, C., AND N. PETERSON
1969 Ethnographic interpretations of the prehistory of western Arnhem Land. *Southwestern Journal of Anthropology* 25:45–67.

WHITE, J. P.
1971 New Guinea and Australian prehistory: the "neolithic problem." In *Aboriginal Man and Environment in Australia*, edited by D. J. Mulvaney and J. Golson. Canberra: Australian National University Press.
1977 Crude, colourless and unenterprising? Prehistorians and their views on the stone age of Sunda and Sahul. In *Sunda and Sahul*, edited by J. Allen, J. Golson, and R. Jones. London: Academic Press.
1979 Melanesia. In *The Prehistory of Polynesia*, edited by J. D. Jennings. Cambridge, Mass.: Harvard University Press.

WHITE, J. P., AND J. F. O'CONNELL
1982 *A Prehistory of Australia, New Guinea and Sahul*. New York: Academic Press.

WILLIAMS, F. E.
1936 *Papuans of the Trans-Fly*. Oxford: Clarendon.

WRIGHT, R. V. S.
1971 Prehistory on the Cape York Peninsula. In *Aboriginal Man and Environment in Australia*, edited by D. J. Mulvaney and J. Golson. Canberra: Australian National University Press.

YEN, D. E.
1971 Construction of the hypothesis for distribution of the sweet potato. In *Man Across the Sea*, edited by C. L. Riley et al. Austin: University of Texas Press.

YEN, D. E., AND J. M. Wheeler
1968 The introduction of taro into the Pacific: the indication of chromosome numbers. *Ethnology* 7: 259–267.